METHODS OF ASCERTAINING THE RENAL FUNCTION, AND ITS IMPORTANCE TO SURGERY.

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Operative genito-urinary surgery has advanced during the last half century to such an extent that operative procedure is carried out almost fearlessly, yet mortality sometimes occurs unexpectedly, due to failure of the renal function, causing a complete suppression of the urine. The subject of the renal function in its relation to surgery is of vast importance, and I will endeavor to portray the different methods of ascertaining the total functional activity of the kidneys, as well as the manner of estimating the function of one kidney.

When a nephrectomy is performed, the essential question is the efficiency of the other kidney, or if the operation is performed on any portion of the lower urinary tract, it is wise to ascertain, as accurately as possible, the renal activity. I will consider the methods of computing the adequacy of the other kidney in nephrectomy, for if one kidney is to be removed, the functional activity of the remaining organ should be known, for the disease may be of bilateral character, and the removal of one organ may bring such a strain upon the other kidney that it will cause a complete suppression of urine, with a fatal result.

The object of ascertaining the functional activity of the kidneys is to learn whether or not the action of the kidneys is lowered to such an extent that an operation will almost invariably prove fatal. Ordinarily, the urine is examined chemically and microscopically in all surgical operations, but this does not always prove whether or not the renal activity is normal or is lowered.

Exploratory incision is not often done at present, due to the fact that the functional properties can not be reliably ascertained.

J. W. Thomson Walker, of London, has shown that exploratory operation of the kidney is inadequate for diagnosis even when the methylene blue test was used, for, on incising the kidney, although the blue color of the urine was strongly marked, he found that upon exposure to the air the blue color of the tissue could not be produced. He had hoped to be able to ascertain the extent of the fibrous changes in the renal substance by the variation of the stain, but as has already been said, no change of coloring was observed, nor did it occur when hydrogen peroxide was used. It is necessary, then, that other methods must be employed to enable the surgeon to know more or less definitely the functional activity of the kidneys.

We will first consider the subject of cryoscopy. The physiologist teaches that the kidneys separate from the blood, and excrete a fluid, the urine, differing in composition from the blood. It has been shown that the function of the kidney is osmotic, and that the osmotic pressure of the urine is greater than that of the blood, therefore the work of the kidney may be ascertained by measuring the osmotic pressure of these two fluids. By osmosis is understood the changing of relations between two chemical solutions of different concentrations, which have for their purpose the equalization of these differences of concentration.

It has been demonstrated that there is an increased concentration of the blood in diseases relative to the kidney, and that with the increase of the osmotic concentration of the blood, there is corresponding decrease of the osmotic pressure of the urine.

Kummel lays great stress upon cryoscopy. Prior to its systematic use in all cases, his mortality for nephrectomy was one in six cases, on account of the absence of insufficiency of the other kidney. Since its use he has not had a single mortality in 148 cases where one kidney was removed.

Cryoscopy of the urine, I believe, to be entirely too uncertain in its results to be of much value, as there is a marked variation in the co-efficient or freezing point in samples of healthy urine; particularly is this so in urine drawn from the bladder.

Any marked deviation from the normal freezing point of the blood, approximately 0.56° C., will be indicative of renal inadequacy. Kummel claims that where the freezing point of the blood is lowered beyond—0.58° C., it shows bilateral kidney disease.

I am inclined rather to accept the views of others that when the freezing point varies between —0.60° C. and —0.65° C., that a diagnosis of the bilateral disease can be made and a nephrectomy is contra-indicated. This procedure, combined with cryoscopy of the urine drawn from the separate kidneys by means of the ureteral catheter, is of considerable value.

The determination of the freezing point of the fluid is usually made by the Beckmann apparatus, which consists of a thermometer marked off in one hundred divisions, each of which is subdivided into one hundred parts. This thermometer is immersed in a glass cylinder in which the fluid to be examined must be stirred continually with a rod of platinum. The glass cylinder with the thermometer and fluid is placed in a freezing mixture at a temperature of —4° C. The fluid is continually kept in motion by the platinum rod. There is an instant when the fluid congeals. As the liquid changes into solid state, heat is expelled, which causes the mercury to rise to a certain point, where it remains suspended for a short time. This is the freezing point of that fluid. The freezing point of distilled water must be ascertained by then subtracting the former from the later; we attain a figure which shows how much lower a temperature the fluid freezes than distilled water.

In demonstrating the freezing point of the blood, a sample of from twenty to fifty cubic centimeters of blood is taken with a hollow needle from the vein of the arm. This is collected in the glass cylinder, and is defibrinated by stirring with a platinum rod. The freezing point is then taken. The freezing point of distilled water should be taken at each examination for the purpose of testing the thermometer. With a little experience this test may readily be made in thirty minutes.

Another important test is the phloridzin test, brought into prominence by Klemperer, who discovered that phloridzin glycosuria did not take place in cases of chronic nephritis, but to Mering we must give the credit of first discovering that injections of phloridzin causes a temporary glycosuria.

Archard and Delmere have demonstrated the fact that phloridzin glycosuria was dependent entirely upon the efficiency of the renal excretion, and that any deviation must be produced by an abnormal functional renal activity.

Kapsammer, after an experience covering 200 cases, declares that phloridzin glycosuria should make its appearance within from ten to fifteen minutes after the phloridzin has been injected into the tissues. A delay of thirty minutes speaks for the essential functional disturbance of both kidneys, and if delayed for forty-five minutes, a nephrectomy is contra-indicated.

Kapsammer uses the following technique: He injects into the tissue .01 gram of phloridzin, and five minutes after the injection he makes his first test of the urine for sugar. This is repeated every five minutes until the sugar makes it appearance, if at all. Personally, I can not conceive how Kapsammer can make such a positive statement from the examination of urine taken from the bladder which has been excreted by both kidneys. I will demonstrate later how this test may be carried out to much better advantage by carefully testing the catheterized specimens from the separate kidneys.

The methylene blue test for determining the activity of the renal function depends for its value upon the following points:

The time of the beginning of the elimination.
The duration of the elimination.
The quantity of coloring matter eliminated.

The colorless derivitive of methylene blue is chromogen, for boiling the urine with acetic acid will change the chromogen into methylene blue. Blue does not enter into the urine until about thirty minutes have transpired. In diseased kidneys the elimination does not begin sometimes until several hours after the injection, and in some cases it does not appear at all. The delay in appearance is entirely proportional to the extent of the pathological lesion occurring in the kidneys.

There are many errors which may arise in this test, for disease of the lower part of the urinary tract may cause delay in the elimination. Obstruction in any part of the lower tract, such as stricture of the urethra, hypertrophy of the prostate, partial or complete ureteral obstruction, has a marked influence in delaying the elimination of the blue, hence errors may arise in estimating the renal functions. In a healthy individual, the time for the total excretion of the blue is, as a rule, from about sixty to seventy-two hours. According to my own observations I have noticed blue in the urine for a week after it has been injected.

Beers, of New York, claims that the blue may be eliminated after many weeks or months in cases of pyelo-nephritis, in the shape of blue stained particles of pus. He further claims that this is absolutely diagnostic of pyelo-nephritis. The methylene blue is deposited in the parenchymatous abscesses, which rupture into the pelvis of the kidney, and thus the blue stained pus is eliminated. I can fully corroborate Beer's statement as to the blue stained particles of pus being evident in a case of pyelo-nephritis and where evident is practically pathognomic of pyelo-nephritis.

Delay in the appearance of methylene blue is supposed to be diagnostic of kidney disease. To make this test more accurate, the quantitative estimation of the blue must be taken into consideration, for the total quantity of blue is decreased in elimination if the function of the kidneys is impaired.

The technique of the methylene blue test is as follows:

Fifteen minims of a five per cent solution of pure methylene blue is injected into the tissue. The injection is usually accompanied with considerable pain.

I might mention here Beer's method of diagnosticating partial or total ureteral obstruction by the indigo-carmin test. He injects, hypodermically, a sterile concentrated aqueous solution of indigo-carmin into the tissues, and by an examination with the cystoscope and ureteral catheter, he is able to diagnosticate ureteral obstruction. I quote from Beer's article as follows:

"A diseased kidney may fail to excrete, or excrete very late, indigo-carmin, without the use of the ureteral catheter, one might be misled to diagnose complete ureteral obstruction in such case though the ureter be patent. Thus it is clear that one method does not exclude the other, and that both must be used together. The ureteral catheter will arouse our suspicion of obstruction, and the indigo-carmin will verify or dispel this."

I find that ureteral obstruction is comparatively a simple condition to diagnosticate by means of a ureteral catheter without the aid of the indigo-carmin test. This method might prove rather misleading, particularly if the kidney was pathologically affected.

The electric current has been used in this work to enable us to reach more definite conclusions as to the efficiency of the kidney function.

It is evident that aqueous solutions offer resistance to the passage of an electrical current, which varies according to their composition. An electrical current passing through the urine owes its conductivity to its mineral elements, and not to the organic constituents. So the conductivity is hindered or enhanced by an increase or diminution of the mineral contents. It has been claimed that this method will enable us to obtain very accurate knowledge concerning the renal functional activity. The same disadvantage may be recited as for some of the other methods, as so many extraneous conditions are liable to upset the general character of the urine.

In taking up the methods that are employed for ascertaining the function of the second kidney where one is known to be diseased, depends entirely upon the knowledge of cystoscopic examination and technique, and the catheterizing cystoscope, for examination of the separate specimens of urine, is essential for a diagnosis. A simple cystoscopic examination of the ureteral orifices may aid us materially in reaching a conclusion as to the function of the second kidney, and the extent of the pathological lesion in the diseased kidney.

Neuman has outlined the diagnostic value of the appearance of the ureteral orifices in a disease of the kidney in such a typical manner that I will give his classifications:

1. When one orifice is altered, and the other normal, the renal lesion is on the side of the abnormal ureter, and the character of the deformity of the orifice may indicate the nature of the renal lesion.

2. Active congestion and swelling of the mucous membrane in the neighborhood of the orifice, and along the line of the ureter, also swelling and pouting of the lips, denote acute irritation of the pelvis or parenchyma of the corresponding kidney.

3. A dilated orifice, the lips acutely congested, while the color of the bladder is little changed, denotes recent and acute inflammation or mechanical irritation in the corresponding pelvis.

4. A dilated orifice, the lips being thickened and only slightly rounded, the mucous membrane between the lips of a dark red color, while the mucous membrane of the bladder is deeply injected and pigmented, especially along the line of the ureter, denotes descending ureteritis with dilatation.

5. An elongated or dilated mouth with hyperemia of the lips indicates acute inflammation of the parenchyma or recent distention of the renal pelvis.

6. A punched-out orifice, marked by thickening of the lips, and induration and congestion of the surrounding mucous membrane, indicates a dilated ureter with ascending ureteritis, the infective process extending along the surface by continuity.

7. A pin-head opening on a well-defined ridge of deeply pigmented mucous membrane, indicates induration of the walls of the ureter from the ureteritis; the infective material being conveyed from the primary focus in the kidney or bladder, principally, through the lymphatic glands and channels.

8. Pin-head contraction of the mouth of the orifice, without other vesicle changes, denotes spasm induced by pressure of a rough calculus impacted in an irritated ureter.

9. Inflammation of the mouth, and thickening of the lips, with inflammatory changes limited to the mucous membrane immediately

surrounding the ureteral orifice, denotes mechanical irritation of long standing.

10. Simple dilatation of the mouth without much thickening of the lips, and with congestion limited to the orifice and neighboring parts, suggest mechanical irritation of recent origin.

To a limited degree these rules as laid down by Neuman will give us certain facts regarding the condition of one or both kidneys, yet they may prove more or less erroneous, for one can not depend upon the ureteric picture for the purpose of drawing conclusion as to the functional activity of the organ. The statistics gathered from the literature regarding kidney lesion is of some value in ascertaining kidney disease, but, however, the statistics of different authorities vary to such a great extent that their value is exceedingly limited.

Morris has found that solitary kidney exists in about one in two thousand six hundred and fifty cases. Kelynack claims that malignant growths occur bilaterally, one in every ten cases.

Polycystic kidney occurs bilaterally, according to Israel, four in four cases, Morris three in seven cases, Dickensen's collected cases, twnety-five in twenty-six. Calculus was bilateral in 50 per cent of cases collected by Legueu; 11.78 per cent of Kuster's cases; 25.3 per cent. of Torre's cases.. Pyelonephritis is bilateral in 83 per cent. of cases, according to Weir, and tuberculous disease is bilateral in about 50 per cent. of cases.

The indigo-carmin test suggested by Joseph is made by injecting four cc. of a four per cent. solution of indigo-carmin into the tissues. Elimination begins after twenty minutes, reaching its height in about thirty minutes, and is complete in about two hours. Examination of the ureteral orifices and the characteristic appearance of the urine pouring forth, together with the depth of staining of the urine, will give some idea of the functional value of the two kidneys. Methylene blue may be used in place of indigo-carmin with practically the same results.

Ureteral catheterization with a collection of the separate specimens of urine for the purpose of making the different tests already mentioned is, to my mind, more valuable than the examination of the urine drawn from the bladder. The quantity of urine passed by the catheter in a specified length of time can not be used as a standard, owing to the fact that the excretion may be influenced by many conditions, such as diet, nervousness and climatic conditions.

The author has seen the excretion of one kidney stop entirely for many minutes, while the other was excreting normally.

Albarran gives the following as a standard analysis of the urine collected from one kidney during an hour in a healthy individual: Quantity, fifty to sixty cubic centimeters; freezing point 1.20° to 1.50° C. Urea twelve to seventeen grams per liter. Sodium chloride, ten to twelve grams per liter.

If two separate specimens of urine have been collected into sterilized test tubes, cryoscopic examination of these specimens will give considerable information regarding the difference of function between the two kidneys. The sympathetic connection between the two kidneys is particularly marked, and it must not be forgotten that the function of a healthy kidney may be more or less influenced by the diseased condition of the other kidney. The functional activity of the known kidney which is healthy, or nearly so, will be decided upon if the volume of the urine from this kidney is greater, and the freezing point shows a greater molecular content than the urine which is collected from the diseased kidney.

The methylene blue test may be performed in the same manner as given above, with the exception that after the injection of the methylene blue the ureters are catheterized, and the separate specimens of urine collected from each kidney. These are watched carefully from time to time as they drain, to show the presence of chromogen or blue. The chromogen should appear in the urine after about fifteen minutes if the kidney is functionating normally, and the blue color should commence in about thirty minutes under the same conditions. If the elimination of the chromogen of blue is delayed, the loss of function of the kidney is proportionate directly to the time of the appearance. Examination of these separate specimens not only are of value in determining the function of the second kidney, if one is known to be diseased, but will give us an insight into the pathological condition of the diseased organ.

The phloridzin test may be carried out along the same lines, and the separate specimens examined every five minutes for the appearance of sugar. In a healthy kidney, the elimination should begin in about fifteen minutes, and if it is delayed thirty minutes, there is marked functional disturbance evident in the kidney, and if delayed for forty-five minutes, removal of the diseased kidney is contra-incated.

The catheterized specimen of urine from each kidney is important from a diagnostic standpoint, for by a careful microscopical examination of these specimens the pathological lesion in one or both kidneys may be accurately diagnosticated, for Heitzmann has proven without a doubt that it is possible to differentiate the epithelial cells that come from the different portions of the genito-urinary tract. He is able to distinguish between pelvic epithelium and epithelium from the convoluted or straight tubules. He also states that if there is pus in the urine, together with desquamated epithelial cells, the pus is coming from that portion of the tract that is desquamating the epithelium, so from a comparative microscopical examination of the urine from the kidneys we will have striking evidence as to whether or not the kidney is free from pathological lesion. If there are present pus and epithelial cells, the comparative relation between those found in the diseased side and those found in the other will give us a sure method of ascertaining the condition of both kidneys.

I believe if the microscope shows a considerable number of pus cells and desquamated epithelial cells from the tubules of the supposed healthy kidney, that a nephrectomy is contra-indicated, as the strain thrown upon the remaining kidney is liable to increase the inflammatory process, or to cause complete suppression of the urine with death, due to uremia.

Barringer, of New York, in an exceedingly scientific contribution to the literature presented at the annual meeting of the American Urological Association in June, 1908, in this city, demonstrates the importance of the urea excretion in determining the functional capacity and pathological changes of the kidneys, particularly the comparison of the total urea excreted by each kidney, and he proves his deductions by the total urea excreted by each kidney, during the same period of time. His conclusions are as follows: "In those cases where no urea is excreted from one side, and where normal, or practically normal urine, flows from the other, the kidney which excretes urea is functionating normally and is already doing the total body work; and according to the duration of the process has undergone more or less compensatory hyperthrophy, and is entirely capable of taking up the total body work after the removal of the diseased kidney." Barringer's deductions are summarized.

(1) In normal cases the total N. comparison gives a more accurate estimate of the functional kidney capacity than the phloridzin test. (The greatest variations in the few normal cases examined being not quite 2 to 1).

(2) In pathological cases: In those cases in which no urea is excreted from one side,

and normal, or practically normal, urine from the other, and in which acute or recent blocking of the ureter or intermittent hydronephrosis may be excluded, we may say that the kidney which excretes urine is functionating normally and is already doing the total body work; and, according to the duration of the process, has undergone more or less compensatory hypertrophy and is entirely capable of taking up the total body work after removal of the diseased kidney. In the kidney which excreted nothing the functional power is entirely lost.

(3) When the total urea excreted from the diseased kidney is less than one-fourth of that excreted by its fellow, we may diagnose grave disease of the affected side and a function of the opposite kidney sufficient to do the body work alone.

(4) The total urea of the diseased side may be twice as much as that of the more normal side, and yet nephrectomy may be undertaken without fear of death from renal insufficiency.

(5) If the total urea of the diseased side be four times as much as that of the more normal side, then there is grave fear of death from uremia following nephrectomy. The borderland cases are those where the total urea of the diseased side is more than twice and less than four times that of the well side.

(6) The twenty-four hour excretion of urea or N. should be considered in all cases. The nearer the total urea of one kidney approximates that of the other, the more importance does a low twenty-four hour excretion of urea assume. The continued retention of urea or N. will probably indicate a danger point.

(7) The general condition of a patient should be carefully considered and any uremic symptoms sought for.

(8) The comparison of the total urea to determine the functional capacity of the kidneys is better than the percentage urea.

(9) Irrespective of the amount of work done by either kidney, there exists a very small class of cases where any known tests can not establish the fact that death from kidney insufficiency is impending. These cases will be revealed, I believe, by a further study of the elimination of the excretory products of the kidneys.

I have endeavored, as far as possible, to dwell briefly upon the different methods of ascertaining the functional activity of one or both kidneys, but I am of the opinion that no one method will give us sufficient information.

I think that all the methods should be carried out, particularly, upon the catheterized specimens from the separate kidneys, and by comparing the different data developed from this examination, we can come to a positive diagnosis as to the relative function of the kidneys. For a quick examination I believe that the phloridzin test of the catheterized specimens, together with a careful microscopical examination, with a study of the characteristic cells in each, with an estimation of the total urea, will give sufficient evidence upon which to base our opinion of the functional activity of the kidneys. If there is a marked devitation from the nomal, the kidneys are functionally inactive, and if this should occur in a supposed healthy kidney, a nephrectomy of the diseased organ is contra-indicated.

The determination of renal function is exceedingly important from the standpoint of surgery, not only on the genito-urinary tract, but to general surgery as well, for hardly a day goes by that I do not hear of a death that occurs after a major surgical procedure due to the insufficiency of the kidneys.